Incorporating Users into System Design

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Goals for today

- Present work-in-progress that integrates engineering, social sciences, and practical applications
- Obtain feedback from workshop participants
- Promote a brainstorming session focusing on:
  - future directions
  - dealing with the complexities of multi-disciplinary research
  - end-user integration: possibilities and challenges
- Determine if there is interest in using CASA’s infrastructure for WAS*IS “intersession” projects
Agenda

- Overview of CASA
- Overview of the End User Integration Project
  - Goals and Approach
  - Weather Scenarios with NWS and EMs
  - In-depth interviews with Emergency Managers
- Break out sessions
- Feedback
Engineering Research Centers

- Research and develop technologies to generate a well-defined class of engineered systems with social and economic impacts.

- Spawn new industries or transform the product lines, processing technologies, or service delivery methodologies for the private and public sectors.

- Faculty, students and industry/practitioners work in a multi-disciplinary environment reflecting real-world technology.

- CASA’s Funding: $17 M NSF; $13 M Universities; $5 M Industry/Practitioner; $5 M state
Weather Radar State-of-the-Art

- Long range (~ 200 km) radars
- Function Autonomously
- Physically large, high power, systems.
- “Sit and spin” surveillance with “data push”
- Middle to upper troposphere coverage with ~ 2 km resolution
Current Limitations: Low-level Radar Coverage Gap

- Earth curvature prevents 72% of the troposphere below 1 km from being observed by NEXRAD.

- Impacts accuracy of QPE, tornado detection, shallow precipitation, for example.

“There is insufficient knowledge about what is actually happening (or is likely to happen) at the Earth’s surface where people live.” [National Research Council 1998]
**CASA:** dense networks of low power radars

- Short range (~ 30 km) radars
- Small, low power, systems
- Radars operate collaboratively
- Adaptive Scanning based on user needs, “data pull”
- Lower troposphere coverage with 100s meter resolution
CASA’s Vision

Demonstrate improved observing, forecasting, warning, response to localized weather hazards through Distributed Collaborative Adaptive Sensing
CASA’s Partners
System Test Beds

Rain mapping, distributed hydro. modeling, flood predicting & response in an urban zone.

Wind mapping (100’s m resolution, 10’s second update) for detecting, pinpointing, forecasting wind events; 30 km node spacing.

Rain, Urban Flooding (Houston)

Wind, storm prediction (Oklahoma)

Rain, mountainous terrain (Puerto Rico – student led)

Off-the-Grid Radar Network for quantitative precipitation estimation (QPE) over complex terrain, student-led project
Research Organization

Sensing
Distributing
Analysis & Prediction
Education

Technical Integration
End-user Integration

Team
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Ellen Bass
Leigh Baum
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Rebecca Fett
William Dorn
Kevin Kloes
Daniel Mark
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Building Test Beds
Multidisciplinary participation in experiments
Design Reviews
Research Retreats
Weekly End User Meetings
Representation on exec committee
End User Integration

- Incorporate end user needs into system design from day one
- Design CASA’s two-way end user interface
- Effective application of weather technology and information for warning and response
- Understand the social and economic impacts of DCAS to support system trade-offs and eventual technology transfer.

Societal Impact: End User Integration links CASA’s science and engineering to innovation and service to society
Who are the users?

Intermediaries
- State Government
- Federal Government

Value Added Data Users
- Emergency Response
- Institutions/Industry

Public

Data

Research
- Academic Institutions/Researchers

Future Partners: Media, transportation, more Private Weather Cos.
Oklahoma Test Bed: Severe Storms

Tornados, Thunderstorms, Straight Line Winds

- 4-node mechanically scanned radar network deployed on cell towers
- 30 km range
- Adaptive scanning
- New detection algorithms
- Modified visualization for radar data
- Pilot User Group: WFO Norman, EMs, Media Researchers

7000 sq. km (90 km long)

2 tornados

4 tornado warnings

50 severe storm warnings
Issues and Methods

Issues:
- Needs/ perceptions of current technology?
- Current decision making process
- Initial adaptive system design
- Changes in decision making because of CASA data
- Effective Communication
- Impacts?

Methods:
- In-depth interviews, focus groups
- Weather Scenarios (actual, simulated)
- Quick Response Research
- Best practices from training orgs: WDTB, OKFirst, experts
- Pilot groups: usage statistics; surveys, focus groups
Our Approach

- Users are part of the design team
- Begin with qualitative studies to uncover key issues because of the number of uncertain variables (new data, new weather features, new visualization, etc.)
- Work with sophisticated users initially
- Show users CASA data in their current operational environment
- Move towards quantitative studies based on information from qualitative studies.
- Training is important
Our Approach

- Identify Decision Response Phases
  - Pre-Storm Environment
  - Watch
  - Warning
  - Event

- What are Decisions Made, Communication Methods, Weather information used, Other information. Pre- and post-DCAS

- Which phases are important for different users?
In-depth Interviews
Disaster Losses

- Disaster losses result from the interaction of:
  - Physical environment (hazard events)
  - Built environment (infrastructure)
  - Social environment (population & community characteristics)

See Mileti, 1999
Vulnerability

Event Incidence
- Type of Event
- Frequency
- How strong
- Where

Societal Exposure
- Population at risk
- Property at risk
- Preparedness
- Resilience

Climate/Weather/Forecast Research Issues

Social Science Research Issues

Societal Impact: Better value and use of scientific research

Modified Pielke and Pielke (1997) Model
Sample and Methodology

- Data were gathered from 72 participants of the 2003 Oklahoma Emergency Management Association’s (OEMA) annual conference.

- Respondents included local, county, and state emergency managers; fire department representatives; local and county government officials; insurance representatives; and other organizations commonly involved in disaster mitigation and preparedness activities.

- It is important to note that this was a convenience, non-random sample.
Objectives of the Survey

- Address issues regarding the perspectives, needs, and problems confronted by emergency management organizations frequently involved in accessing weather information, radar support, emergency warning information, organizational limitations, and so on.
Some Surveys Results:
Problems and Concerns

- Inadequate radar coverage
- Updating of weather information is slow
- Limited warning time
- Inadequate communication with the public or between and within agencies
- Lack of training and experience among personnel
The survey results allowed us to develop a detailed and comprehensive instrument or semi-structured questionnaire which was used for in-depth interviews with a broad pool of local, county, and state emergency managers and representatives from the National Weather Service (NWS).
In-depth Interviews

- Purposive and Snowball sampling
- Sample consisted of 49 personnel from emergency management community, the National Weather Service, Spotters, and Ham Radio Operators, among others
- In-depth interviews lasting from 1.5 to 2.5 hours
- Almost 1,000 pages of interview transcripts!
Geographical Distribution of In-depth interviews Conducted with the End-User Community
Hazard Threats

Historically, floods cause more damage and deaths. However, emergency managers interviewed consider tornados the most dangerous weather event given their unpredictable nature.

“If I don’t give the warning for a flood, I’m still going to be here tomorrow...if I don’t blow the sirens before the tornado hits the city limits, I won’t be here tomorrow” (Emergency Manager)

Flood mitigation measures may potentially provide respondents and their constituencies with a “false sense of security” thus increasing their vulnerability to such events.
More frequent updates of radar data

“Quicker updates [of radar data] would be the number one thing for me. Because it’s a long five minutes when you have a tornado coming down your throat here, and you’re hitting the reload button...” (Emergency Manager)
Tracking and Visualization

- Precise tracking of tornadoes:
  
  "It would be great to be able to say that there is a large vortex up to a quarter mile wide centered at this intersection, and five minutes from now it’s going to be at this intersection, and to be very specific in that way."

- Visualization:
  
  - Real-time weather information
  - Sophisticated users want access to ‘raw’ radar data
  - Enhanced graphics
  - User-friendly information and graphics
False Alarms

- Regarding False alarms:
  - Over warning is preferred
  - However, there is concern about the impact of FARs at the organizational level

“In fact, there are parts of the country now where tornado warnings get routinely issued and there are places that I know where 30 or more tornado warnings have been issued in a day and there wasn’t a single tornado associated with it. You figure that at some point in time, that’s going to have an impact” (Emergency Manager)
False Alarms

- An NWS representative indicated:
  
  “Well, false alarms are always a problem to some degree, because when you tell someone there’s a threat and nothing materializes, there’s some element of that that may be harmful to your credibility...you run the risk of people losing confidence to some degree that you know what you’re talking about.”

- According to historical data from NWS, the current FARs for tornadoes is .675 for the state of Oklahoma and .756 for the United States
Some emergency managers discussed the negative impact of having more lead-time:

“Well if it was going to be one extreme or the other and I couldn’t find that perfect time in there and it was either going to be 6 or 8 minutes before something hits or 20 minutes before it hits I’d rather go for the earlier time because you don’t want people jumping in their cars and trying to get somewhere.

“Well, for lack of anything else, the lead time is, right, what’s the maximum time that you can tell me that a tornado may strike that town, or that part of the city. Right now in Oklahoma, 20-30 minutes is a good warning time. That should be more than enough to prevent anyone from getting killed or injured—should be.”
Redundancy of Information

- Resiliency of the communication infrastructure is needed

- Having multiple information sources can be a benefit
  - However, multiple information sources can also lead to confusion and impact public response, particularly when contradictory and incorrect information is provided by some sources
Spotters

- A heavy reliance on spotters, particularly in rural areas, was reported by emergency managers:

  “One without the other [technology and spotters] is a disaster asking itself to happen. If you were an emergency manager with no spotters, you will definitely send the people to cover so often that it will get to the point where it’s cry wolf.”

  “With the spotters in the field, you not only give the people correct, absolute, real life information but you also give the National Weather Service the same thing.”
Spotters

- However, emergency managers reported some problems that may be generated by spotters, particularly regarding:
  - Absence of adequate training
  - Reliability of spotter’s reports:

  “…an awful lot of spotters I’ve found over the years are unreliable. People have to be good…but out of the 10 or 12 they send out, there are only two of them [spotters] [that] you want to listen to.”
The Role of the Media

- Respondents agreed that the media plays an important role in the communication of disaster information. However, they also identified a number of problems with the media:

  “they’re [the media] interested in revenue of course, that’s what they’re interested in...you try to give them all the information [during a severe hazard event] and then you listen to what they put out and it’s like ‘that’s what I said?’

  “It’s a media market issue. The television stations are very sensitive to where their population demographics lie and they’re not going to devote a lot of air time to a storm that’s far from the people because they get complaints,” reported an NWS representative.
Public Response

People do not always respond appropriately to weather information and warnings:

“But a tornado warning you probably got about 30% [individuals] that if they see it coming their way, I mean at their house, they may do something. The other 70% will probably go outside and look at it.”
Limited Resources: Internet Access

- Emergency managers depend quite extensively on internet-based weather information sources.

- However, offices located in rural areas may not have access to broadband connection; limited access to any kind of internet services.

  "Of course there [are] tornadoes that happen in every place but in our [or] your rural area out here we don’t have the resources that they have in the city." (Emergency Manager in rural area)
Limited Resources

- Competing tasks and employment responsibilities for emergency managers impact training, preparedness, and response

- Limited budget and resources as highlighted by emergency managers:

  “We are spread as emergency managers, not only in weather, but [in] many other functions also. So, therefore, we do the best we can with the training we’ve got and have been given.”

  “There are no funds, the county doesn’t have any money so we get a little bit of help on the fire service part of it but, other than that, most of ours [funds] are city provided...all of our vehicles are equipped, paid by us out of our pockets.”
Limited Resources

- The lack of resources has negative implications for the growth and development of emergency managers, their professional training and, therefore, on their ability to adequately prepare and respond to hazard events in their communities.

- Consequently, communities and their populations may be negatively impacted. Emphasizing this point, a respondent in the upper echelons of the emergency management bureaucracy indicates:

  “Oh, absolutely it impacts. If, and we’ve heard this from a lot of our emergency managers, my boss won’t let me take off time to go to the training. He’s got to take his vacation time to go to the conferences and the training that is important to do the emergency management job...is the employer willing to fund him, give them paid time off, probably not in most cases. So does it impact? Sure!”
Education & Communication Issues

- Public awareness and education and response to severe weather warnings must be understood and improved.
- Examine communication within and between emergency management organizations, the media, and the general public.
- How to effectively communicate with an increasingly diverse population.
Conclusions

- Improving weather forecasts, reducing FAR's, and increasing lead times is only part of the equation in determining the ultimate effectiveness of organizational and individual preparedness and response to hazards.
- Parts of data gathered from interviews was used in system design.
Emergency Manager
Weather Scenarios
Experiment Background

Begin to understand how
Emergency Managers may use CASA data.

- How does CASA data fit into their decision making process?
- How does it complement current NEXRAD data?
- What are the training needs for interpreting and using CASA data?
- How does the quicker update time impact EMs interpretation and tasks accomplished?
- How does having GIS information influence the decisions?
Background

- Critical Decision method used (Klein, Calderwood & MacGegor, 1989) to gather information (Human Factors)
- Conducted two scenarios based on historical weather event and asked EMs to “talk through” their decision process and complete questionnaires.
- Scenario 1: NEXRAD, GIS info, NWS warning information.
- Scenario 2, NEXRAD, Data, and “faux” CASA data (Doppler On Wheels), GIS info, warning information.
- 11 EMs participated. Mostly sophisticated EMs from within and upstream of Oklahoma test bed.
Scenario 1 Demo

Scenario 2 Demo
Very Early Findings/Trends

- Overall reaction to CASA data is very positive: scale of data matches, scale of EM decisions.
- Street-level information and high resolution data enabled them to distinguish among different geographic locations (e.g. school vs. hospital) for notification and first responder deployment.
- For the case studied, warning decision did not change.
- Training needed on recognizing features in CASA data, and reconciling CASA and NEXRAD data.
- Update time could be an issue; some lost situational awareness.
- CASA will be used in conjunction with spotters, NEXRAD and media.
Questions

1. What is the best way to work with the NWS, Emergency Managers, and other future users on the paradigm shift (technology, observing strategy, communications) generated by CASA?

2. The test beds are geographically small, and we are working with a small number of sophisticated users. What should strategies be used for broadening participation, and generalizing results?

3. What kinds of metrics should we establish to quantify the impacts of the system from detection to response?
Questions

4. How can our findings be effectively integrated into mitigation, preparedness, response and communication strategies?

5. What strategies could be used to enhance the development and implementation of GIS for this project?

6. What strategies or ideas can be developed to foster or promote multidisciplinary research and the integration of social sciences within CASA?
Back Ups
Overview
LONG-TERM VISION

SYSTEMS DESIGN

• Pre- and Post -DCAS behavior/ response
• Two-Way Interface Design (Visualization/Data)
• User Policy Module
• Training

IMPACTS

• Impacts on user decision making process: warnings, organizational response
• Public Response (other sources of funding)
• Social, Economic Impact
• Education/Outreach

Linking societal response and quantitative engineering models

Methods: surveys, in-depth interviews, weather scenarios, test bed participation, quick response surveys
CASA Data
User Driven System Design

- Users: NWS Forecast Office, Emergency Managers, and Media (planned) for Oklahoma test bed
- Severe weather [severe thunder storms, hail, and tomados] impacts 90% of EMs in Oklahoma.
- Tornado Pinpointing cited by EMs as important for managing deployment and protection of first responders.
- Tornado Anticipation cited by NWS and EMs as most important for increasing lead time.
- All users cited more frequent updates of radar data as a critical need.
- There is a need for lower troposphere, high resolution data for detecting: convergence lines, gust fronts, straight line winds.

Sources: Structured surveys (N=72) of Oklahoma Emergency Managers; In-Depth Interviews (N=37) of EMs and NWS using snowball sampling and content analysis to extract information; test bed user group.